

Application guidelines

Inverter scroll compressors **VZH hybrid manifold**

R410A



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General information

Scope

The application guideline describes the operating characteristics, design features and application requirements for hybrid manifolded of the Danfoss SH fixed-speed compressor and the VZH inverter compressor in air-conditioning and heat pump applications.

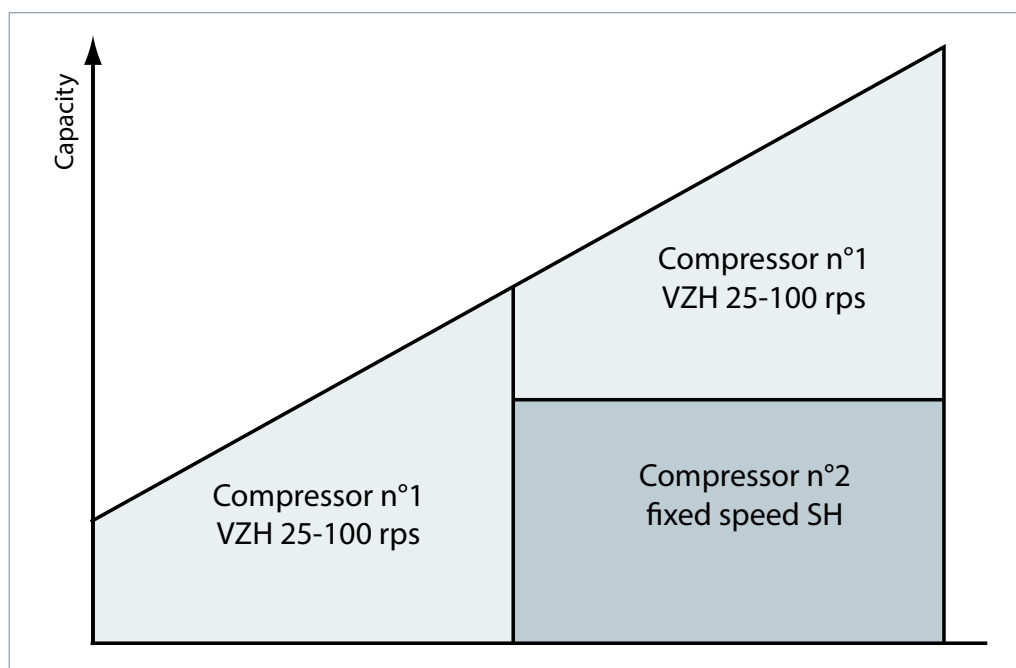
To ensure proper parallel installation and running conditions, the following recommendations must be followed:

- It is essential to respect all the instructions given in these guidelines; please refer to the instruction leaflet supplied with each compressor and the application guidelines for single compressors.
- For additional system components related to specific application requirements, the supplier recommendations must always be respected.

Benefits

A parallel compressor installation refers to a system of interconnected compressors with a common suction line and a common discharge line. The technique of mounting compressors in parallel is also called manifolding. The hybrid manifolding in this application guideline refers to the manifolding of the Danfoss inverter compressor (VZH) and fixed speed compressor (SH), which has several benefits.

The main reason is reduced operating cost through controlling capacity and power consumption to a greater extent. This is achieved by both staggering the compressor switch-on sequences and regulating the speed of the inverter compressor which allows the parallel system to continuously match its power with the capacity needed.



A second reason for manifolding the inverter compressor and the fixed speed compressor is improved part-load efficiency. In the variable speed+fixed speed parallel installation, the system can run either only the inverter compressor at lower load or both the inverter and fixed speed compressors at a higher load with the fixed speed compressor operating at 100% load.

Therefore, it will be possible to achieve a higher part-load efficiency.

Thirdly, the capacity of the hybrid manifolded system can be widely regulated, for example 10% to 100%. The continuous capacity regulation allows for accurate temperature control and a comfortable indoor environment.

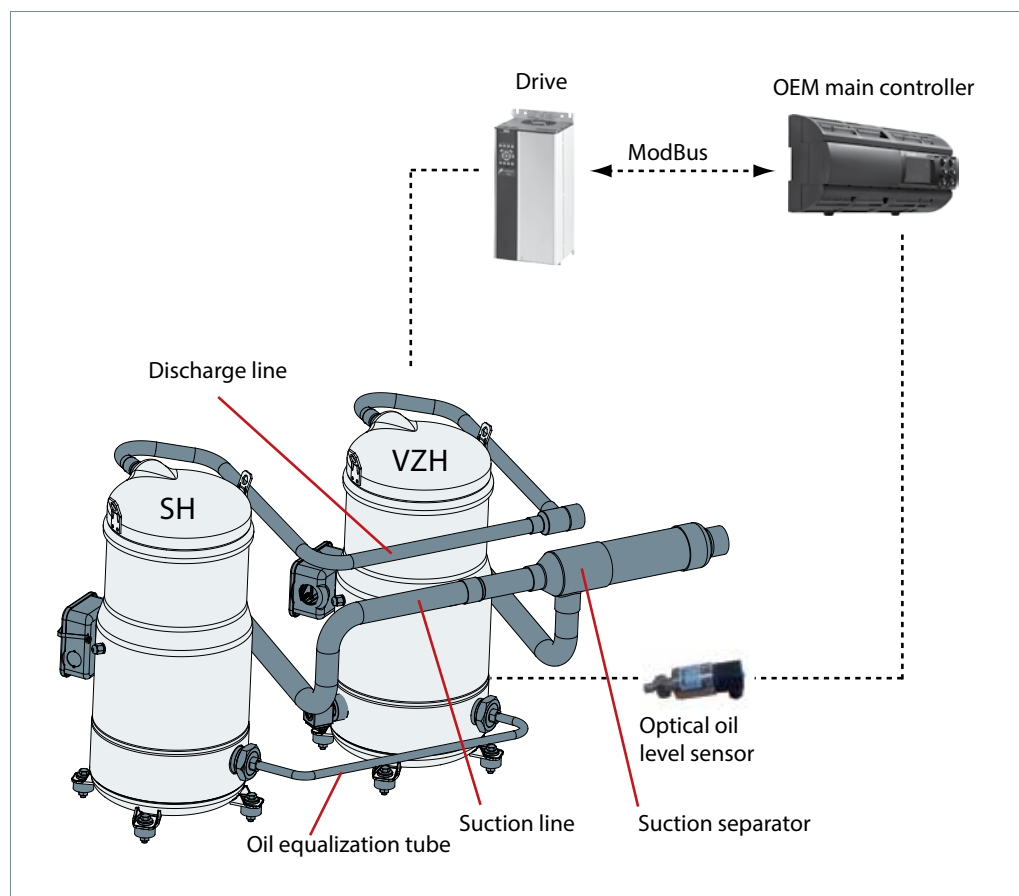
Oil management concept

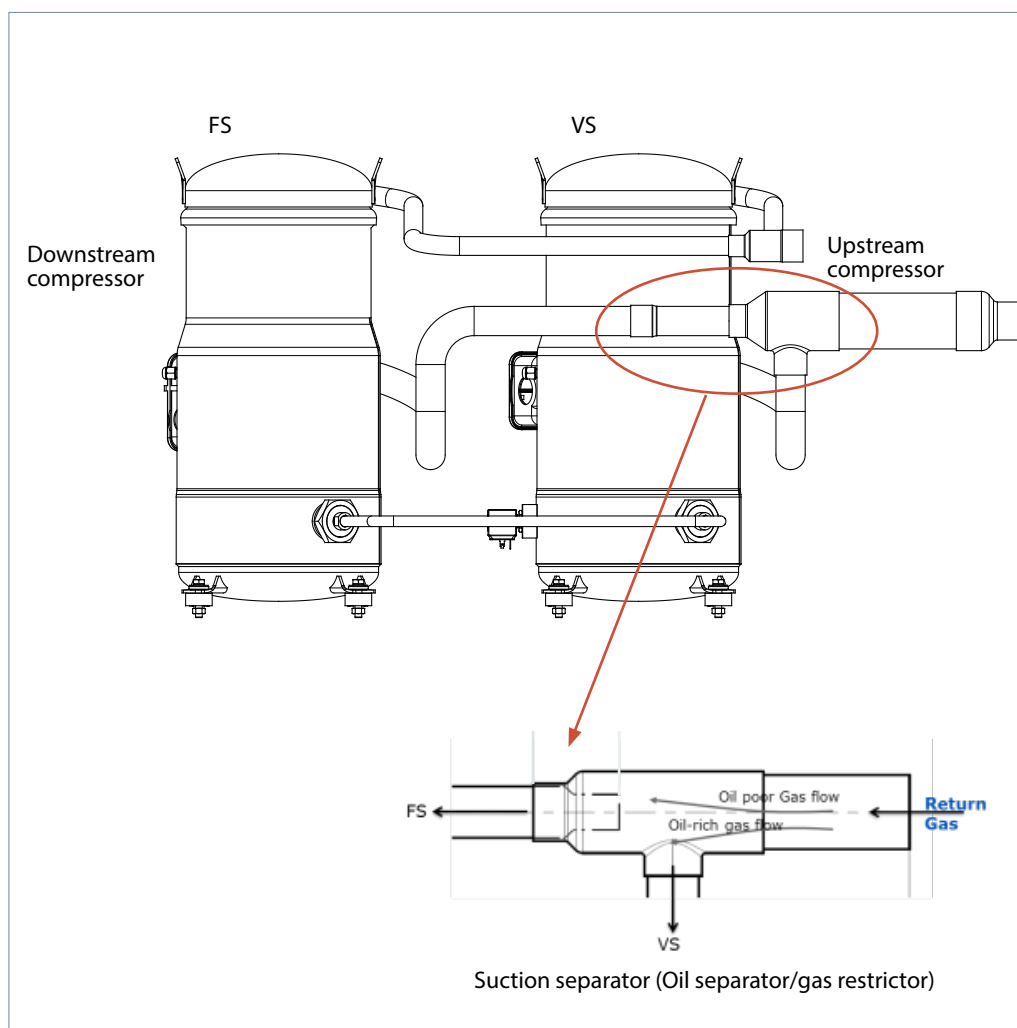
System configuration

Hybrid manifolding systems use the dynamic system for oil balance. The suction connections between the two individual compressors are interconnected by a special suction separator design that allows most of oil feed into variable speed compressors.

An optical-electrical oil level sensor fixed in a variable speed compressor monitors the compressor oil level.

If the oil level drops below the limit, the OEM main controller activates the oil management logic.





The hybrid manifold system uses the dynamic system for oil balance.

The suction connections of the two individual compressors are interconnected by a suction separator that integrates with the suction oil separator and the gas restrictor. The variable speed compressor (VS) is installed in the upstream position which appears first on suction line and fixed speed compressor (FS) is installed on downstream position.

The oil which clings back along the main suction line is separated by the suction separator which

returns most of the oil in the suction gas to the upstream compressor. The suction separator creates a slight pressure drop to ensure lower sump pressure between two compressors are well balance when fixed speed compressor is ON and the inverter compressor is running at maximum speed. When the variable speed compressor runs at any frequency below maximum speed, the sump pressure in the fixed speed compressor is lower than the variable speed compressor, and driven by the sump pressure difference, the excess oil from the variable speed compressor runs into the fixed speed compressor sump.

Oil management concept

Approved hybrid tandem configurations and capacity range

Different configurations of hybrid tandems are possible. All VZH models (high/low pressure ratio/ different voltage) could be manifolded with fixed speed compressors.

Danfoss VSD : VZH compressor Drive™ 380-480 Volt

| Model | Description | FS: 50Hz, VS:100Hz | | FS: 60Hz, VS: 100Hz | |
|--------|--------------|--------------------|------|---------------------|------|
| | | kW | TR | kW | TR |
| VZH178 | VZH088+SH90 | 68.9 | 19.6 | 73.9 | 21.0 |
| VZH208 | VZH088+SH120 | 77.7 | 22.1 | 83.7 | 23.8 |
| VZH257 | VZH117+SH140 | 97.8 | 27.8 | 105.2 | 29.9 |
| VZH278 | VZH117+SH161 | 101.6 | 28.9 | 110.1 | 31.3 |
| VZH301 | VZH117+SH184 | 106.2 | 30.2 | 115.7 | 32.9 |
| VZH350 | VZH170+SH180 | 137.5 | 39.1 | 147.4 | 41.9 |
| VZH354 | VZH170+SH184 | 137.0 | 39.1 | 146.0 | 41.9 |
| VZH410 | VZH170+SH240 | 151.9 | 43.2 | 164.9 | 46.9 |
| VZH465 | VZH170+SH295 | 164.6 | 46.8 | 179.3 | 51.0 |

TR: Ton of Refrigeration

Refrigerant: R410A

Standard rating conditions: ARI standard

Evaporating temperature: 7.2°C

Superheat: 11.1k

Condensing temperature: 54.4°C

Subcooling: 8.3k

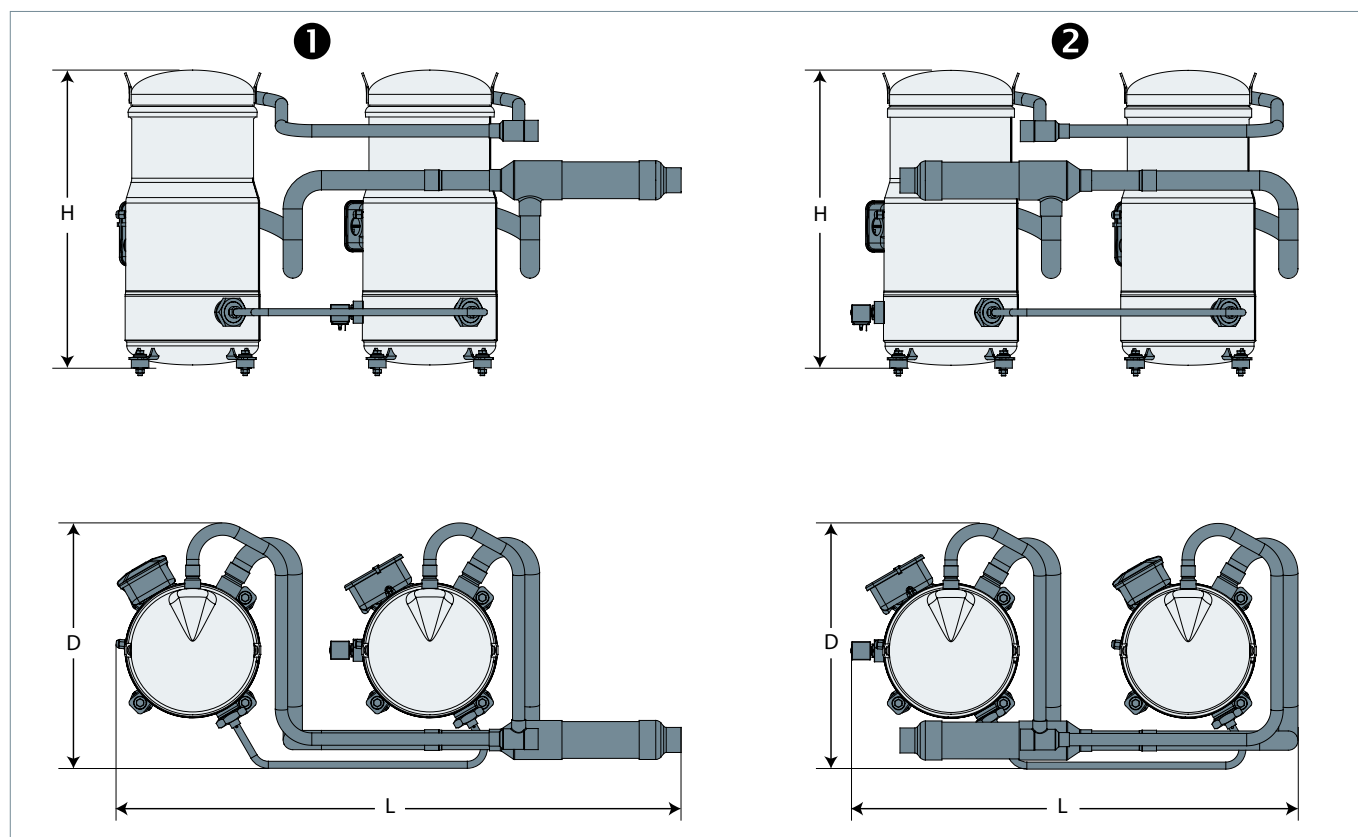
Subject to modification without prior notification

Data given for motor code G compressor – for full data details and capacity tables, please refer to Coolselector2

www.coolselector.danfoss.com

Dimensions

Tandem



| Tandem model | Composition | Outline drawing number | Suction | Discharge | L (mm) | D (mm) | H (mm) |
|--------------|----------------|------------------------|---------|-----------|--------|--------|--------|
| VZH178 | VZH088 + SH090 | 1 8560108 | 1"5/8 | 1"3/8 | 1011 | 445 | 482 |
| | | 2 8560109 | 1"5/8 | 1"3/8 | 810 | 445 | 482 |
| VZH208 | VZH088 + SH120 | 1 8560104 | 1"5/8 | 1"3/8 | 1011 | 445 | 540 |
| | | 2 8560105 | 1"5/8 | 1"3/8 | 811 | 445 | 540 |
| VZH257 | VZH117 + SH140 | 1 8560106 | 1"5/8 | 1"3/8 | 1024 | 445 | 540 |
| | | 2 8560107 | 1"5/8 | 1"3/8 | 811 | 445 | 540 |
| VZH278 | VZH117 + SH161 | 1 8560106 | 1"5/8 | 1"3/8 | 1024 | 445 | 540 |
| | | 2 8560107 | 1"5/8 | 1"3/8 | 811 | 445 | 540 |
| VZH301 | VZH117 + SH184 | 1 8556183 | 1"5/8 | 1"3/8 | 1116 | 445 | 555 |
| | | 2 8556184 | 1"5/8 | 1"3/8 | 811 | 445 | 555 |
| VZH350 | VZH170 + SH180 | 1 8556181 | 2"1/8 | 1"5/8 | 1233 | 550 | 682 |
| | | 2 8556182 | 2"1/8 | 1"5/8 | 953 | 550 | 682 |
| VZH354 | VZH170 + SH184 | 1 8556188 | 2"1/8 | 1"5/8 | 1241 | 550 | 682 |
| | | 2 8556189 | 2"1/8 | 1"5/8 | 890 | 550 | 682 |
| VZH410 | VZH170 + SH240 | 1 8556181 | 2"1/8 | 1"5/8 | 1233 | 550 | 682 |
| | | 2 8556182 | 2"1/8 | 1"5/8 | 953 | 550 | 682 |
| VZH465 | VZH170 + SH295 | 1 8556181 | 2"1/8 | 1"5/8 | 1233 | 550 | 682 |
| | | 2 8556182 | 2"1/8 | 1"5/8 | 953 | 550 | 682 |

Tandem configurations are achieved by assembling individual compressors

Design pipe

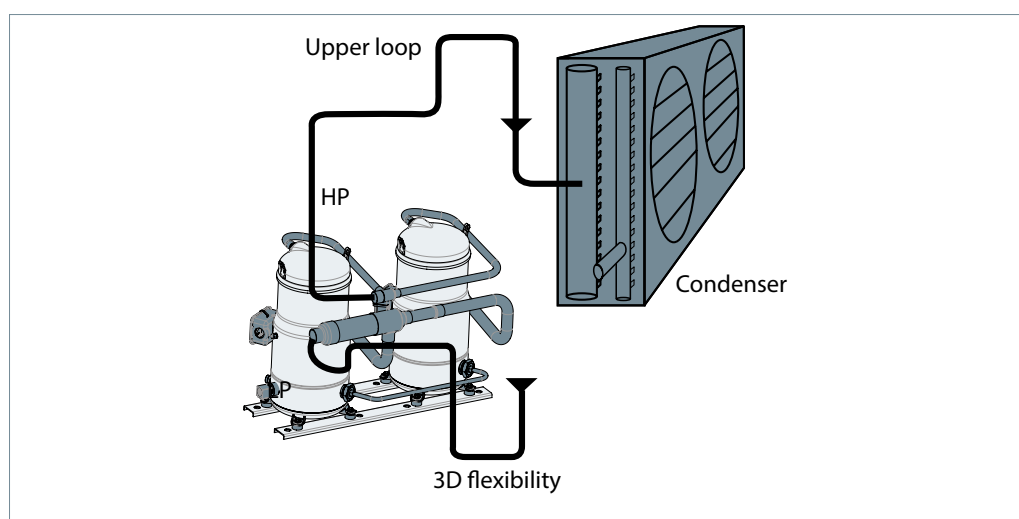
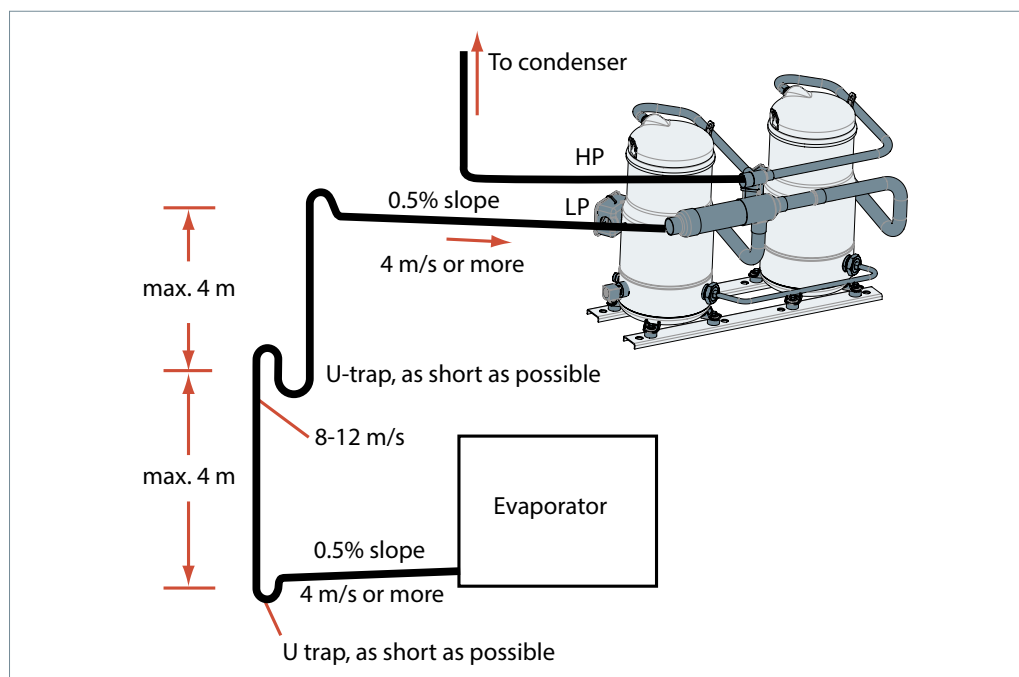
General requirements

Proper piping practices should be employed to:

1. Ensure adequate oil return, even under minimum load conditions (fixed speed compressor off, variable speed compressor at minimum speed, minimum evaporating conditions). If minimum refrigerant velocity cannot be reached, it is strongly recommended that an oil separator is used. For a validation test, the see section "Manage oil in the circuit".

2. Prevent condensed liquid refrigerant from draining back into the compressor when stopped (discharge piping upper loop). For validation tests, see the section "Manage off-cycle migration".

General recommendations are described in the figures below:



3. Piping should be designed with adequate three-dimensional flexibility to avoid excess vibration. It should not be in contact with the surrounding structure, unless a proper tubing mount has been installed. For more information

on noise and vibration, see the section "Sound and vibration management" in the application guideline for Danfoss VZH scroll compressors (FRCC.PC.023).

Design pipe

Suction on left



Fixed speed

Suction on right



Fixed speed

| Fixed speed | Variable speed | Tandem model | Suction direction | Hz of FS compressor | Suction separator code | Tandem accessory kit code |
|-------------|----------------|--------------|-------------------|---------------------|------------------------|-------------------------------------------------------------------------------|
| SH090 | + | VZH088 | Left/Right | 50 | 120Z0676 | 120Z0653 (with 24V oil level sensor) 120Z0654 (with 230V oil level sensor) |
| | | | | 60 | 120Z0675 | 120Z0653 (with 24V oil level sensor) 120Z0654 (with 230V oil level sensor) |
| SH120 | + | VZH088 | Left/Right | 50 | 120Z0664 | 120Z0651 (with 24V oil level sensor) 120Z0652 (with 230V oil level sensor) |
| | | | | 60 | 120Z0658 | 120Z0651 (with 24V oil level sensor) 120Z0652 (with 230V oil level sensor) |
| SH140 | + | VZH117 | Left/Right | 50 | 120Z0666 | 120Z0653 (with 24V oil level sensor) 120Z0654 (with 230V oil level sensor) |
| | | | | 60 | 120Z0665 | 120Z0653 (with 24V oil level sensor) 120Z0654 (with 230V oil level sensor) |
| SH161 | + | VZH117 | Left/Right | 50 | 120Z0665 | 120Z0653 (with 24V oil level sensor) 120Z0654 (with 230V oil level sensor) |
| | | | | 60 | 120Z0674 | 120Z0653 (with 24V oil level sensor) 120Z0654 (with 230V oil level sensor) |
| SH184 | + | VZH117 | Left/Right | 50 & 60 | 120Z0656 | 120Z0651 (with 24V oil level sensor) 120Z0652 (with 230V oil level sensor) |
| SH180 | + | VZH170 | Left/Right | 50 & 60 | 120Z0657 | 120Z0649 (with 24V oil level sensor) 120Z0650 (with 230V oil level sensor) |
| SH184 | + | VZH170 | Left | 50 | 120Z0683 | 120Z0682 (with 24V oil level sensor) 120Z0681 (with 230V oil level sensor) |
| | | | | | 120Z0683 | 120Z0682 (with 24V oil level sensor) 120Z0681 (with 230V oil level sensor) |
| | | | Left | 60 | 120Z0655 | 120Z0682 (with 24V oil level sensor) 120Z0681 (with 230V oil level sensor) |
| | | | | | 120Z0655 | 120Z0682 (with 24V oil level sensor) 120Z0681 (with 230V oil level sensor) |
| | | | Right | 50 | 120Z0687 | 120Z0682 (with 24V oil level sensor) 120Z0681 (with 230V oil level sensor) |
| | | | | | 120Z0687 | 120Z0682 (with 24V oil level sensor) 120Z0681 (with 230V oil level sensor) |
| SH240 | + | VZH170 | Left/Right | 50 & 60 | 120Z0657 | 120Z0649 (with 24V oil level sensor) 120Z0650 (with 230V oil level sensor) |
| | | | | | | 120Z0649 (with 24V oil level sensor) 120Z0650 (with 230V oil level sensor) |
| SH295 | + | VZH170 | Left/Right | 50 & 60 | 120Z0655 | 120Z0649 (with 24V oil level sensor) 120Z0650 (with 230V oil level sensor) |

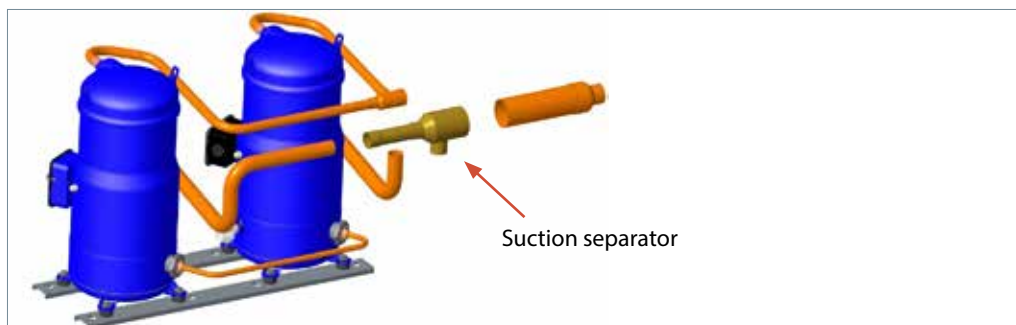
Note:

The tandem accessory includes oil equalization kits and oil level sensor. For compressors that need a UL certificate, please order the accessory kit with the 24V oil level sensor.

Design pipe

Suction separator

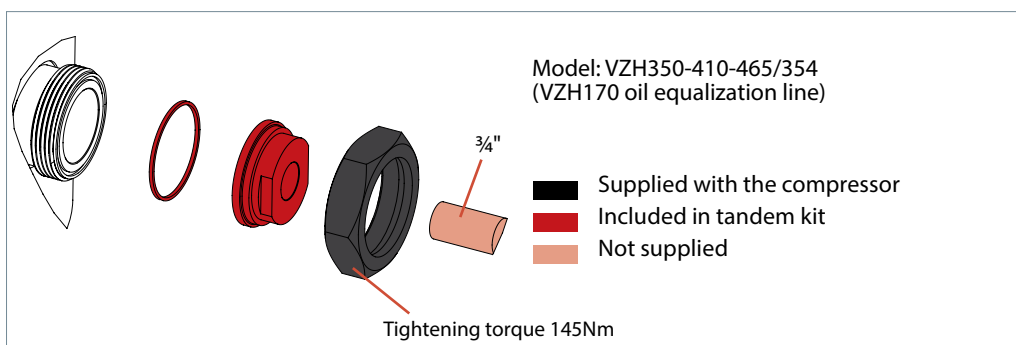
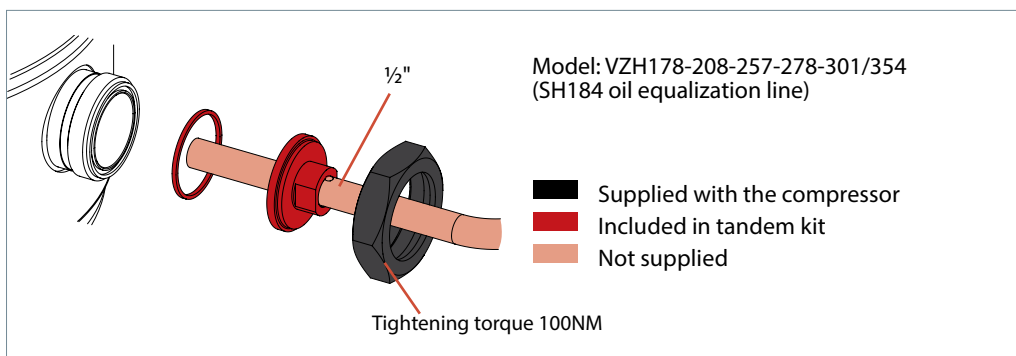
The suction connections of the two individual compressors are interconnected by a suction separator, which is supplied as an accessory.



Oil equalization design

The two compressors are connected by a 1/2" or 3/4" oil equalization pipe. To fix the oil equalization connection rotolock, use the adaptor sleeves

and the seal gasket which were included in the tandem accessory kit.



Design compressor mounting

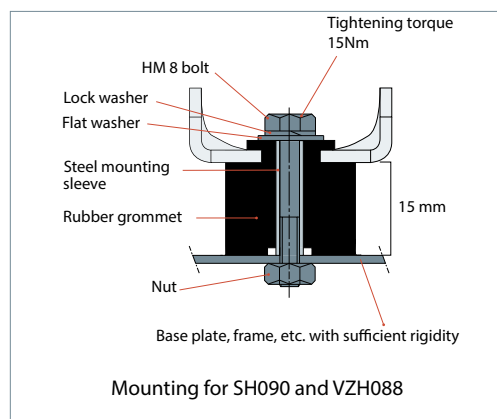
General requirements

The tandem is fixed to the frame using the flexible grommets that are supplied with

the compressor or which are included in the accessory kit.

VZH178 Mounting feet

The compressors are fixed to the frame using rubber grommets, mounting sleeves, and washers (supplied with the compressors).

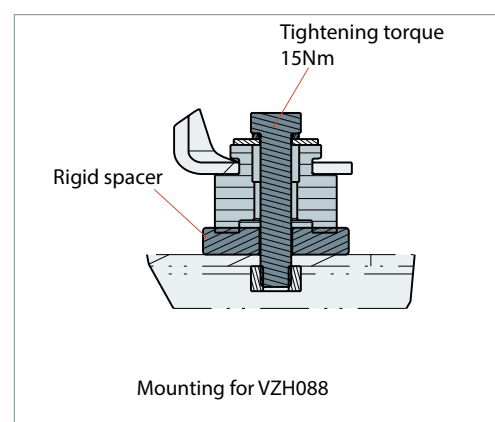
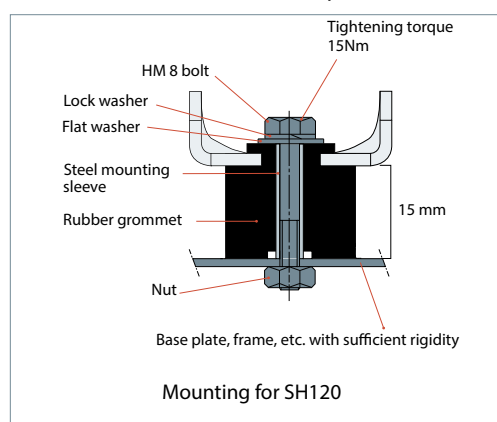


VZH208 Mounting feet

The compressors are fixed to the frame using rubber grommets, mounting sleeves, and washers (supplied with the compressors).

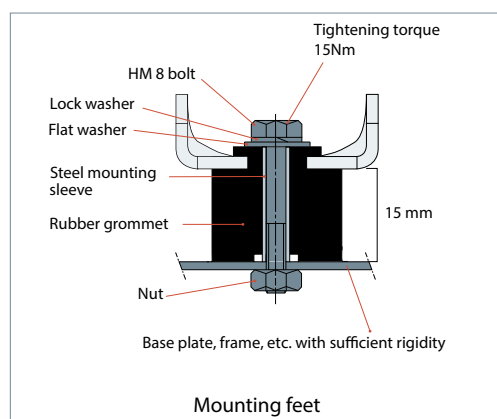
Because VZH088 is 7 mm smaller than SH120, in order to ensure that the oil equalization

connection is at the same level for both compressors, an additional 7mm rigid spacer must be added under VZH088 (see drawing. The 7 mm rigid spacer is supplied with the tandem accessory kit).



VZH257 / VZH278 Mounting feet

The compressors are fixed to the frame using rubber grommets, mounting sleeves, and washers (supplied with the compressors).



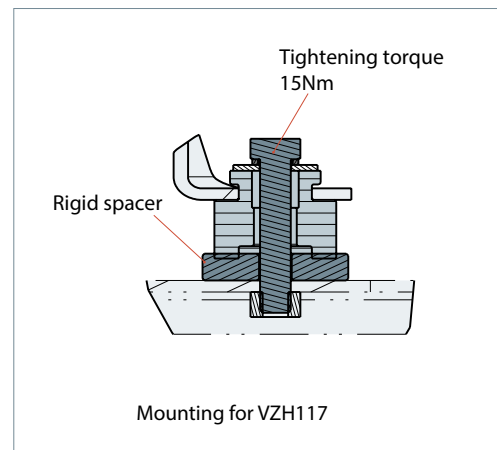
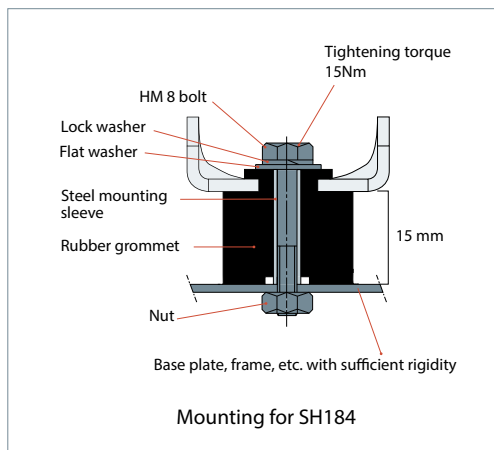
Design compressor mounting

VZH301 Mounting feet

The compressors are fixed to the frame using rubber grommets, mounting sleeves, and washers (supplied with the compressors).

Because VZH117 is 7 mm smaller than SH184, in order to ensure that the oil equalization

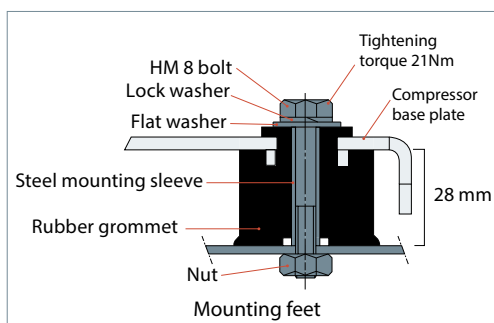
connection is at the same level for both compressors, an additional 7mm rigid spacer must be added under VZH117 (see drawing. The 7 mm rigid spacer is supplied with the tandem accessory kit).



VZH350 / VZH410 / VZH465 Mounting feet

The compressors are fixed to the frame using rubber grommets, mounting sleeves, and washers. The VZH mounting kits are supplied

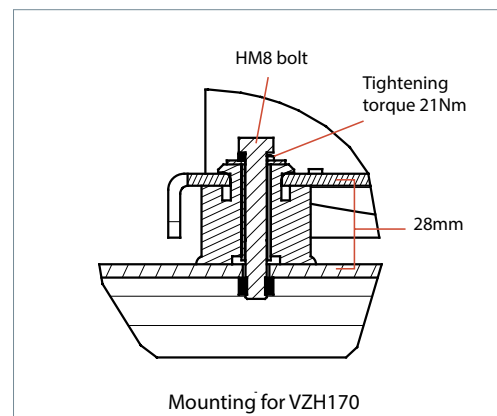
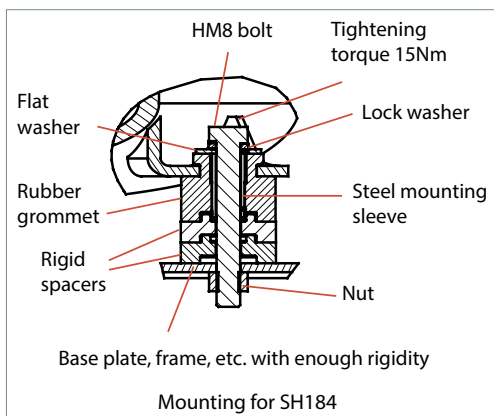
with the VZH compressor, and SH mounting kits are included in the tandem accessory kit.



VZH354 Mounting kit

The compressors are fixed on the frame using rubber grommets, mounting sleeves, washers (delivered with the compressors).

Because SH184 is 14mm smaller than VZH170, in order to have oil equalization connection at the same level for both compressors, two additional 7mm rigid spacers must be added under SH184 (See below drawing, two 7mm rigid spacers are provided in Tandem accessory kit).

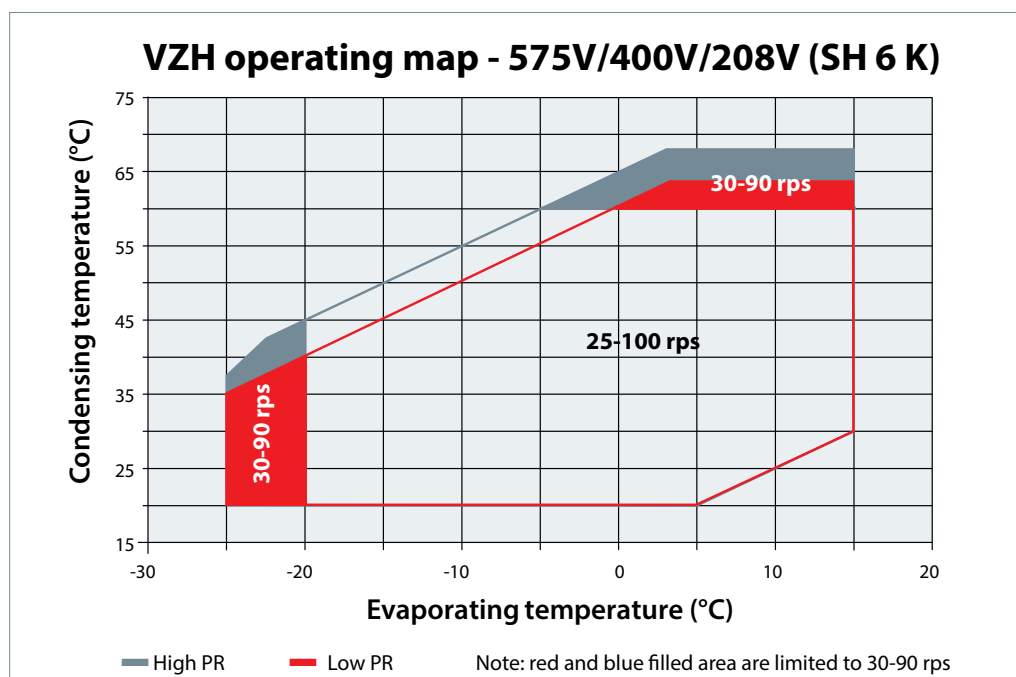


Manage operating envelope

Requirement

The operating envelope for hybrid manifolding is shown below, and guarantees reliable operation of the compressor for steady-state operation.

The steady-state operation envelope is valid for a suction superheat of between 5K and 30K.



Note: for 380V power input, permitted highest condensing temperature will decrease accordingly:

- High PR: 25-100 rps, condensing temperature from 60°C to 56°C; 30-90 rps, condensing temperature from 68°C to 65°C
- Low PR: 25-100 rps, condensing temperature from 60°C to 56°C; 30-90 rps, condensing temperature from 63°C to 62°C.

| Pressure settings | | R410A |
|-----------------------------------------------|--------|-----------------------------------------------------------------------|
| Working range high side | bar(g) | High PR 13.5-44.5 Low PR 13.5-40 |
| Working range low side | bar(g) | 2.3-11.6 |
| Maximum high pressure safety switch setting* | bar(g) | 45 |
| Minimum low pressure safety switch setting | bar(g) | 1.5 |
| Minimum low pressure pump-down switch setting | bar(g) | 1.5 bar below nominal evaporating pressure with minimum of 2.3 bar(g) |

*Maximum allowable pressure on high pressure side according to PED regulation.

LP and HP safety switches must never be bypassed nor delayed and must stop all the compressors.

The LP safety switch auto restart must be limited to five times within 12 hours.

The HP safety switch must be reset manually.

Depending on application operating envelope, it is necessary to define the HP and LP limits within the operating envelope and using the pressure setting table above.

Manage superheat

During normal operation, refrigerant enters the compressor as a superheated vapour. Liquid flood back occurs when some of the refrigerant entering the compressor is still in a liquid state.

Liquid flood back can cause oil dilution and, in extreme situations, lead to liquid slugging that can damage compression parts.

Requirement

In the steady-state condition, the expansion device must ensure a suction superheat of between 5k and 30k.

System evaluation

| Basic unit single exchanger as evaporator and condenser | Advance unit Multiple exchangers as evaporator or condenser (heat-recovery, exchanger, four-pipe chiller...) | Non-reversible | Reversible | Suction accumulator | Test |
|------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|----------------|------------|---------------------|--------------------------------------------------|
| X | | X | | Optional | Pass liquid flood back test |
| X | | - | X | Recommended | Pass liquid flood back test Pass defrost test |
| | X | X | | Mandatory | Pass liquid flood back test |
| | X | | X | Mandatory | Pass liquid flood back test Pass defrost test |

Test, criteria and solutions

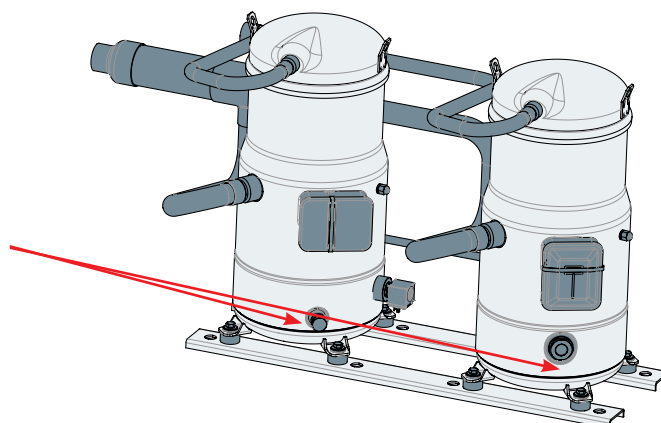
| Test No | Purpose | Test condition | Pass criteria | Solutions |
|------------------------|----------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Liquid flood back test | Steady-state | <p>Liquid flood back testing must be carried out under expansion valve threshold operating conditions:</p> <p>Variable speed On at min.speed / fixed speed Off</p> <p>Running conditions corresponding to the lowest foreseeable evaporation, and highest foreseeable condensation</p> <p>In case of reversible system, the test must be done in both cooling and heating mode</p> <p>If advanced unit, test in all possible configurations</p> | Suction superheat >5k | <p>1. Check expansion valve selection and setting (EXV) check measurement chain and PID.</p> <p>2. Add a suction accumulator*</p> |
| | Transient | <p>Tests must be carried out in the most unfavourable conditions:</p> <ul style="list-style-type: none"> fan staging compressor ramping up and down | The oil superheat must not be more than 30 sec below the safe limit defined in the dilution chart (see graph below) | |
| Defrost test | Check liquid flood back during defrost cycle | The defrost test must be carried out in the most unfavorable conditions (at 0°C evaporating temperature) | The oil superheat must not be more than 30 sec below the safe limit defined in the dilution chart (see graph below) | <p>1. In reversible systems, the defrost logic can be worked out to limit the liquid flood back effect. (For more details see "Control logic")</p> <p>2. Add a suction accumulator*</p> |

* A suction accumulator offers protection by trapping the liquid refrigerant upstream from the compressor. The accumulator should be sized at least 50% of the total system charge. The suction accumulator dimensions can impact oil return (gas velocity, oil return, hole size etc.), and therefore the oil return has to be checked according to the "Manage oil in the circuit" section.

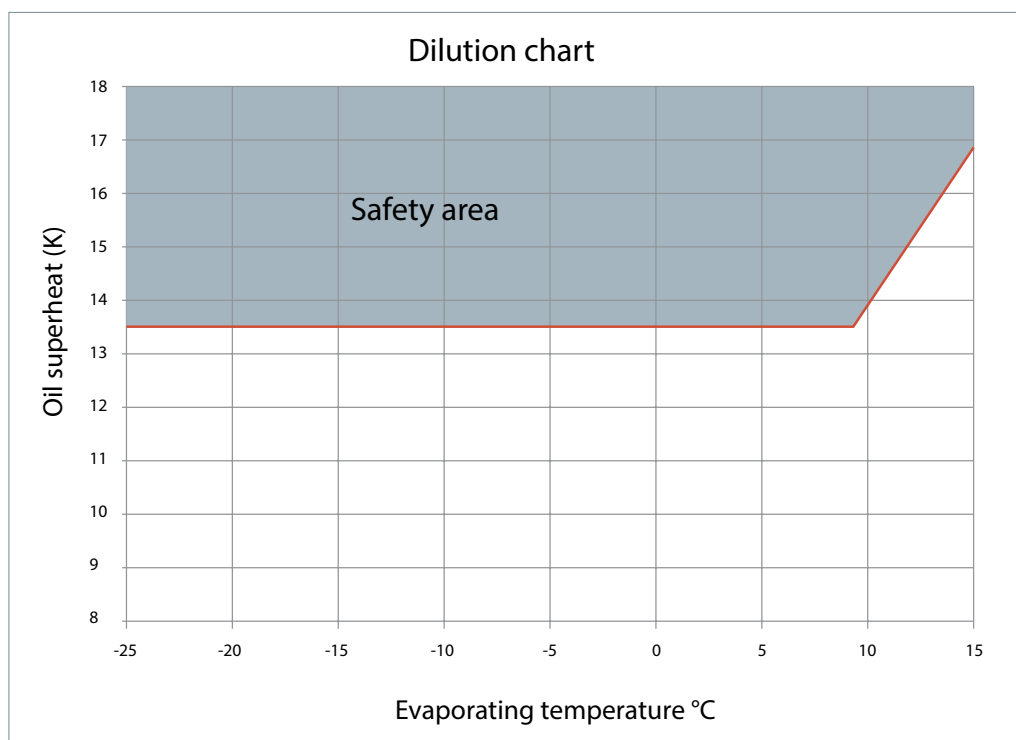
Manage superheat

The oil temperature sensor must be placed between the oil sight glass and the compressor baseplate for fixed speed compressor, and beside the oil level sensor for the variable speed compressor.

Use a little thermal paste to improve conductivity. The sensor must also be thermally insulated correctly from the ambience.



Oil superheat is defined as:
(Oil temperature - Evaporating temperature)



Manage off-cycle migration

Off-cycle refrigerant migration happens:

- when the compressor is located at the coldest part of the installation, and refrigerant vapour then condenses in the compressor, or

- directly in the liquid phase as the result of gravity. When the compressor starts running again, the refrigerant diluted in the oil generates poor lubrication conditions. In extreme situations, this leads to liquid slugging that can damage compressor parts.

Requirement

The amount of liquid refrigerant in the compressors must not exceed the charge limit.

System evaluation

| Non split | Split | Below charge limit | Above charge limit | Surface sump heater* | Non-return valve | Liquid line solenoid valve** | Pump-down cycle*** |
|-----------|-------|--------------------|--------------------|----------------------|------------------|------------------------------|--------------------|
| X | | X | | Optional | Optional | Mandatory | Optional |
| X | | | X | Mandatory | Mandatory | Mandatory | Recommended |
| | X | - | - | Mandatory | Mandatory | Mandatory | Recommended |

*Surface sump heater

The surface sump heaters are designed to protect the compressor against off-cycle refrigerant migration.

Additional heater power or thermal insulation is needed in case the ambient temperature falls below -5°C and the wind speed is above 5 m/sec. The heater must be turned on whenever all the compressors are off.

Surface sump heater accessories are available from Danfoss (see the "Accessories" section).



**Liquid line solenoid valve (LLSV)

An LLSV is used to isolate the liquid charge on the condenser side, thereby preventing refrigerant being transferred to the compressor during off-cycles. The electronic expansion valve that closes automatically including in power shut down situation can replace the LLSV. The quantity of refrigerant on the low-pressure side of the system can be further reduced by using a pump-down cycle in association with the LLSV.

***Pump-down cycle

By decreasing pressure in the sump, pump down:

- evacuates refrigerant from the oil
- sets the sump saturating pressure much lower than the ambient temperature, and as a result, refrigerant condensation is avoided in the compressor.

Pump-down switch setting must be set higher than 2.3 bar(g).

For more details on pump-down cycle see the section "Control logic".

Refrigerant charge limit table

| Compressor models | Refrigerant charge limit (kg) |
|----------------------------------------------------------------|-------------------------------|
| VZH088 + SH090 / VZH088 + SH120 | 8.0 |
| VZH117 + SH140, VZH117 + SH161, VZH117 + SH184 | 10.0 |
| VZH170 + SH184, VZH170 + SH180, VZH170 + SH240, VZH170 + SH295 | 15.0 |

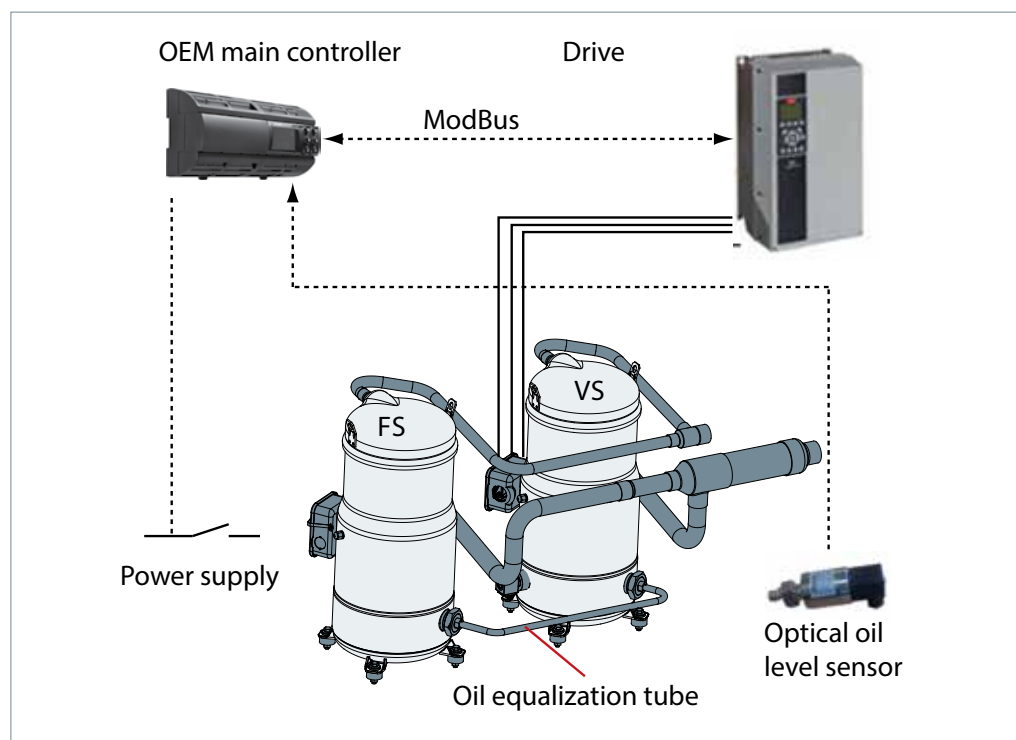
Manage oil in the circuit

Oil management system for hybrid manifolding

The oil management system architecture for hybrid manifolding is described below.

An oil equalization tube between the variable speed compressor and the fixed speed compressor is used to maintain the oil balance.

An oil level sensor need to be installed on the variable speed compressor. The oil level sensor monitors the compressor oil level and send oil level signal to OEM main controller. When oil level is below the minimal, OEM controller enter in oil management mode to recover a proper oil level in compressor. If oil level cannot be recovered, controller stop the system.



Oil management logic

In order to maintain the proper oil level in the compressors, an oil management control logic needs be implemented in the OEM controller.

The oil management control logic must include three steps.

1. In the case of low oil level detection, an oil balance mode (Variable speed on, Fixed speed off) is activated to recover oil from fixed speed to variable speed.

2. If oil level cannot be recovered in VS compressor, controller go to Oil boost Mode (Variable speed on, Fix Speed on) in order to recover oil trapped in system.

3. If the oil level is still below the limit after a full oil balance action and oil boost action have been completed, the controller must enter in protection mode, and stop the system in alarm.

For more detailed oil management logic, please refer to "Oil management logic" in the annex.

Manage oil in the circuit

Requirement

Fixed speed compressor: The oil level must be visible or full in the sight glass when the compressor is running and when all the compressors in the circuit are stopped.

Variable speed compressor: This compressor is equipped with an oil level switch located at the minimum acceptable level. If the oil level drops below this limit, the controller must follow the oil logic (See "Oil management logic" in the annex).

R Fixed speed compressor oil returned status need be monitored in qualification test by normal OSG on FS compressor or additional oil level switch placed on FS OSG, the OEM should make sure enough oil in FS compressor by test on their own unit.

System evaluation

| Basic unit Single exchanger as evaporator and condenser | Advance unit Multiple exchangers as evaporator or condenser (heat-recovery, exchanger, four-pipe chiller...) | Non-reversible | Reversible | Non-split | Split | Oil separator | Test |
|------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|----------------|------------|-----------|-------|---------------|---------------------|
| X | | - | - | X | | Optional | Pass tests 1 & 2 |
| | X | - | - | X | | Recommended | Pass tests 1 & 2 |
| - | - | - | - | - | X | Mandatory | Pass tests 1, 2 & 3 |

Test, criteria and solutions

| Test no. | Purpose | Test condition | Pass criteria | Solutions |
|----------|-----------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 | Oil return test under minimum mass flow | <p>Variable speed On at minimum speed / Fixed speed Off Running condition corresponds to lowest foreseeable evaporation, and highest foreseeable condensation on the system</p> <p>Running for 6 hours</p> <p>For a reversible system, perform the test in both heating and cooling modes. If it is an advanced unit, test in all possible configurations</p> <p>Variable speed On at minimum speed / Fixed speed On Running condition corresponding to lowest foreseeable evaporation, and highest foreseeable condensation on the system</p> <p>Running for 6 hours</p> <p>For a reversible system, perform the test in both heating and cooling modes. If it is an advanced unit, test in all possible configurations</p> | <p>Variable speed: No lack of oil alarm</p> <p>No more than two oil boost cycles per hour</p> <p>Variable speed: No lack of oil alarm</p> <p>Fixed speed: Oil visible in sight glass</p> | <p>Look for potential oil trap</p> <p>Increase oil boost duration</p> <p>Top up with oil, generally 4% of the total system refrigerant charge (in weight)</p> <p>Oil separator can be added</p> |
| 2 | Check oil management control logic is working | <p>Variable speed On at 50 rps for VZH088-117 or 40 rps for VZH170 / Fixed speed On</p> <p>Running conditions corresponding to the lowest foreseeable evaporation, and the highest foreseeable condensation on the system.</p> <p>Running for 6 hours</p> <p>For a reversible system, perform the test in both heating and cooling modes. If it is an advanced unit, test in all possible configurations</p> | <p>No more than two oil balance cycles per hour</p> <p>Fixed speed: Oil visible in sight glass</p> | <p>Look for potential oil trap</p> <p>Increase oil boost duration</p> <p>Top up with oil, generally 4% of the total system refrigerant charge (in weight). If more than 4% is used, look for a potential oil trap in the system</p> <p>Oil separator can be added</p> |
| 3 | Oil return in split system | <p>Since each installation is unique, tests 1 and 2 cannot fully validate the oil return</p> <p>The oil level must be checked and adjusted at commissioning</p> | <p>Fix speed: Oil visible in sight glass</p> <p>No more than two oil balance cycles per hour</p> | <p>The oil separator is mandatory</p> <p>Pay special attention to "Piping design"</p> <p>Top-up with oil, generally 4% of the total system refrigerant charge (in weight). If more than 4% is used, look for a potential oil trap in the system</p> |

Control logic

Safety control logic requirements

| Safeties | Tripping conditions | | Re-start conditions | |
|--------------------------------------------|----------------------------------------------------------------------------|-----------------------------------|--------------------------------------------------|---------------------------------------------------------------|
| | Value | Time | Value | Time |
| HP switch | See the pressure settings table in the "Manage operating envelope section" | Immediate, no delay No by-pass | Conditions back to normal Switch closed again | Manual reset |
| LP safety switch | | | | Max. 5 auto resets during a 12-hour period, then manual reset |
| Electronic module (only for SH180-240-295) | Contact M1-M2 opened | | | Max. 5 auto resets during a 12-hour period, then manual reset |

Cycle rate limit requirements

Danfoss requires a minimum compressor running time of 3 minutes to ensure proper oil return and sufficient motor cooling. Additionally, the compressor service life is based on max. 12 starts per hour.

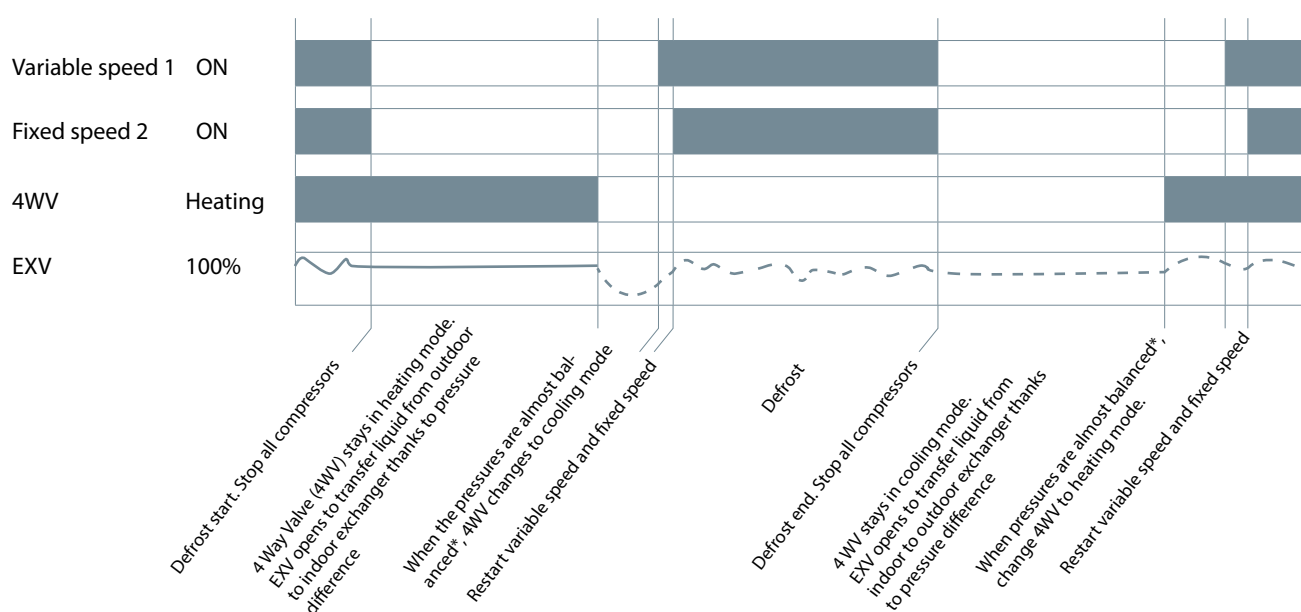
Therefore, to meet these two requirements, a three-minute (180 sec.) time-out is recommended.

Defrost logic recommendations

In reversible systems, the defrost logic can be worked out to limit the effects of liquid flood back by:
1. Running at full load during defrost to share the liquid refrigerant between all the compressors.

2. Transferring the liquid refrigerant from one exchanger to the other thanks to pressures.

The following defrost logic combines both advantages:



* EXV opening degree and time have to be set to keep a minimum pressure for 4 way valve moving.

Control logic

Pump-down logic recommendations

Pump down is initiated prior to shutting down the last compressor on the circuit by de-energizing a liquid line solenoid valve or closing electronic expansion valve. When suction pressure reaches the cut-out pressure, the compressor is stopped.

Two types of pump-down exist:

- One-shot pump down (preferred): When the last compressor in the circuit stops, the suction pressure is falls by 1.5 bar below the nominal evaporating pressure with a minimum of 2,3 bar(g). Even if the suction pressure increases again, the compressor will not restart.
- Continuous pump-down: Compressor restarts automatically when the suction pressure increases.

Assembly line procedure

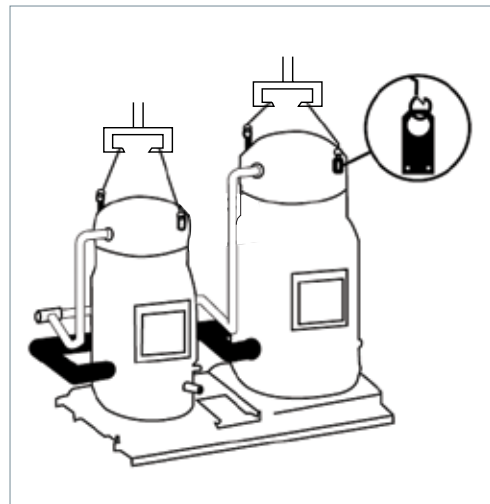
The installation and service procedure for a parallel system are similar to basic single-system installations. The selection of additional system components for parallel installations follows

the basic system common rules. Please refer to the application guidelines for Danfoss VZH scroll compressors (FRCC.PC.023) for detailed installation and service procedures.

Handling

Danfoss Commercial Compressors recommends using the lift and handling devices as shown on the right, and that the following procedure be used to prevent damage:

- There are two lifting rings on each compressor. Use all four rings.
- Maximum loads authorized per sling and for the hoist hook must not be lower than the weight of the assembly.
- If the tandem unit is already installed as a complete installation, it must never be lifted using the lifting rings on the compressors.



Ordering information

Compressor ordering codes

To build a complete tandem installation, the customer must order two must order 2

compressors, one suction separator and one tandem accessory kit.

Danfoss VZH and SH scroll compressors can be ordered in either industrial packs or in single packs. Please refer to the single compressor

application guideline for compressor ordering information (FRCC.PC.023 for VZH, FRCC.PC.007 for SH).

Accessory ordering codes

The suction separator and tandem kit can be ordered using the code numbers listed in the table below. The suction separator and

the tandem kit selection should be based on compressor model, frequency of fixed speed compressor and oil level switch voltage.

| Tandem model | Variable speed compressor | Fixed speed compressor | Suction direction | Suction separator | | | Tandem accessory kit | | |
|--------------|---------------------------|------------------------|-------------------|--------------------|----------|-----------|-----------------------------|----------|-----------|
| | | | | Hz (FS compressor) | Code | Pack size | Voltage of oil level switch | Code | Pack size |
| VZH178 | VZH088 | SH090 | Left/Right | 50 Hz | 120Z0676 | 1 | 24V | 120Z0653 | 1 |
| | | | | 60 Hz | 120Z0675 | 1 | 230V | 120Z0654 | 1 |
| | | | | | | | 24V | 120Z0653 | 1 |
| | | | | | | | 230V | 120Z0654 | 1 |
| VZH208 | VZH088 | SH120 | Left/Right | 50 Hz | 120Z0664 | 1 | 24V | 120Z0651 | 1 |
| | | | | 60 Hz | 120Z0658 | 1 | 230V | 120Z0652 | 1 |
| | | | | | | | 24V | 120Z0651 | 1 |
| | | | | | | | 230V | 120Z0652 | 1 |
| VZH257 | VZH117 | SH140 | Left/Right | 50 Hz | 120Z0666 | 1 | 24V | 120Z0653 | 1 |
| | | | | 60 Hz | 120Z0665 | 1 | 230V | 120Z0654 | 1 |
| | | | | | | | 24V | 120Z0653 | 1 |
| | | | | | | | 230V | 120Z0654 | 1 |
| VZH278 | VZH117 | SH161 | Left/Right | 50 Hz | 120Z0665 | 1 | 24V | 120Z0653 | 1 |
| | | | | 60 Hz | 120Z0674 | 1 | 230V | 120Z0654 | 1 |
| | | | | | | | 24V | 120Z0653 | 1 |
| | | | | | | | 230V | 120Z0654 | 1 |
| VZH301 | VZH117 | SH184 | Left/Right | 50 Hz | 120Z0656 | 1 | 24V | 120Z0651 | 1 |
| | | | | 60 Hz | 120Z0656 | 1 | 230V | 120Z0652 | 1 |
| | | | | | | | 24V | 120Z0651 | 1 |
| | | | | | | | 230V | 120Z0652 | 1 |
| VZH350 | VZH170 | SH180 | Left/Right | 50 Hz | 120Z0657 | 1 | 24V | 120Z0649 | 1 |
| | | | | 60 Hz | 120Z0657 | 1 | 230V | 120Z0650 | 1 |
| | | | | | | | 24V | 120Z0649 | 1 |
| | | | | | | | 230V | 120Z0650 | 1 |
| VZH354 | VZH170 | SH184 | Left | 50 Hz | 120Z0683 | 1 | 24V | 120Z0682 | 1 |
| | | | | 60 Hz | 120Z0655 | 1 | 230V | 120Z0681 | 1 |
| | | | | | | | 24V | 120Z0682 | 1 |
| | | | | | | | 230V | 120Z0681 | 1 |
| | | | Right | 50 Hz | 120Z0687 | 1 | 24V | 120Z0682 | 1 |
| | | | | 60 Hz | 120Z0687 | 1 | 230V | 120Z0681 | 1 |
| VZH410 | VZH170 | SH240 | Left/Right | 50 Hz | 120Z0657 | 1 | 24V | 120Z0649 | 1 |
| | | | | 60 Hz | 120Z0657 | 1 | 230V | 120Z0650 | 1 |
| | | | | | | | 24V | 120Z0649 | 1 |
| | | | | | | | 230V | 120Z0650 | 1 |
| VZH465 | VZH170 | SH295 | Left/Right | 50 Hz | 120Z0655 | 1 | 24V | 120Z0649 | 1 |
| | | | | 60 Hz | 120Z0655 | 1 | 230V | 120Z0650 | 1 |
| | | | | | | | 24V | 120Z0649 | 1 |
| | | | | | | | 230V | 120Z0650 | 1 |

GENERAL INFORMATION

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ORDERING INFORMATION

Accessories

Suction separator



| Code no. | Description | Application | Packaging | Pack size |
|----------|-----------------------------------|---------------------------------------------------------------------------------|-------------|-----------|
| 120Z0676 | Hybrid manifold suction separator | VZH178 (50Hz) - right/left suction | Single pack | 1 |
| 120Z0675 | Hybrid manifold suction separator | VZH178 (60Hz) - right/left suction | Single pack | 1 |
| 120Z0664 | Hybrid manifold suction separator | VZH208 (50Hz) - right/left suction | Single pack | 1 |
| 120Z0658 | Hybrid manifold suction separator | VZH208 (60Hz) - right/left suction | Single pack | 1 |
| 120Z0666 | Hybrid manifold suction separator | VZH257 (50Hz) - right/left suction | Single pack | 1 |
| 120Z0665 | Hybrid manifold suction separator | VZH257 (60Hz) - right/left suction VZH278 (50Hz) - right/left suction | Single pack | 1 |
| 120Z0674 | Hybrid manifold suction separator | VZH278 (60Hz) - right/left suction | Single pack | 1 |
| 120Z0656 | Hybrid manifold suction separator | VZH301 (50/60Hz) - right/left suction | Single pack | 1 |
| 120Z0657 | Hybrid manifold suction separator | VZH350 (50/60Hz) - right/left suction, VZH410 (50/60Hz) - right/left suction | Single pack | 1 |
| 120Z0655 | Hybrid manifold suction separator | VZH465 (50/60Hz) - right/left suction, VZH354 (60Hz) - left suction | Single pack | 1 |
| 120Z0683 | Hybrid manifold suction separator | VZH354(50Hz) - left suction | Single pack | 1 |
| 120Z0687 | Hybrid manifold suction separator | VZH354(50/60Hz) - right suction | Single pack | 1 |

Tandem accessory kit



| Code no. | Description | Application | Packaging | Pack size |
|----------|------------------------------------------------------------------------|----------------------------------------------|-------------|-----------|
| 120Z0653 | Oil level sensor 24V AC/DC, sleeves, gaskets | VZH178-257-278 with 24V oil level sensor | Single pack | 1 |
| 120Z0654 | Oil level sensor 230V AC, sleeves, gaskets | VZH178-257-278 with 230V oil level sensor | Single pack | 1 |
| 120Z0651 | Oil level sensor 24V AC/DC, sleeves, gaskets | VZH208-301 with 24V oil level sensor | Single pack | 1 |
| 120Z0652 | Oil level sensor 230V AC/DC, sleeves, gaskets | VZH208-301 with 230V oil level sensor | Single pack | 1 |
| 120Z0649 | Oil level sensor 24V AC/DC, sleeves, gaskets, grommets, washers, bolts | VZH350-410-465 with 24V oil level sensor | Single pack | 1 |
| 120Z0650 | Oil level sensor 230V AC, sleeves, gaskets, grommets, washers, bolts | VZH350-410-465 with 230V oil level sensor | Single pack | 1 |
| 120Z0681 | Oil level sensor 230V AC, sleeves, gaskets, grommets, washers, bolts | VZH354 with 230V oil level sensor | Single pack | 1 |
| 120Z0682 | Oil level sensor 24V AC, sleeves, gaskets, grommets, washers, bolts | VZH354 with 24V oil level sensor | Single pack | 1 |

Oil level sensor



| Code no. | Description | Application | Packaging | Pack size |
|----------|----------------------------|------------------------------------|-------------|-----------|
| 120Z0561 | Oil level sensor 24V AC/DC | VZH088-117-170 manifolding version | Single pack | 1 |
| 120Z0562 | Oil level sensor 230V AC | VZH088-117-170 manifolding version | Single pack | 1 |

Accessories

Surface Sump Heater



| Code no. | Description | Application | Packaging | Pack size |
|----------|--------------------------------------------------------------|-----------------------------------------|-----------|-----------|
| 120Z0388 | Surface sump heater, 80W, 24V, CE, UL | VZH088-117 SH090-105-120-140-161-184 | Multipack | 8 |
| 120Z0389 | Surface sump heater, 80W, 230V, CE, UL | | Multipack | 8 |
| 120Z0390 | Surface sump heater, 80W, 400V, CE, UL | | Multipack | 8 |
| 120Z0391 | Surface sump heater, 80W, 460V, CE, UL | | Multipack | 8 |
| 120Z0402 | Surface sump heater, 80W, 575V, CE, UL | | Multipack | 8 |
| 120Z0360 | Surface sump heater + bottom insulation, 56 W, 24 V, CE, UL | VZH170 SH180 | Multipack | 6 |
| 120Z0376 | Surface sump heater + bottom insulation, 56 W, 230 V, CE, UL | | Multipack | 6 |
| 120Z0377 | Surface sump heater + bottom insulation, 56 W, 400 V, CE, UL | | Multipack | 6 |
| 120Z0378 | Surface sump heater + bottom insulation, 56 W, 460 V, CE, UL | | Multipack | 6 |
| 120Z0379 | Surface sump heater + bottom insulation, 56 W, 575 V, CE, UL | | Multipack | 6 |

GENERAL INFORMATION

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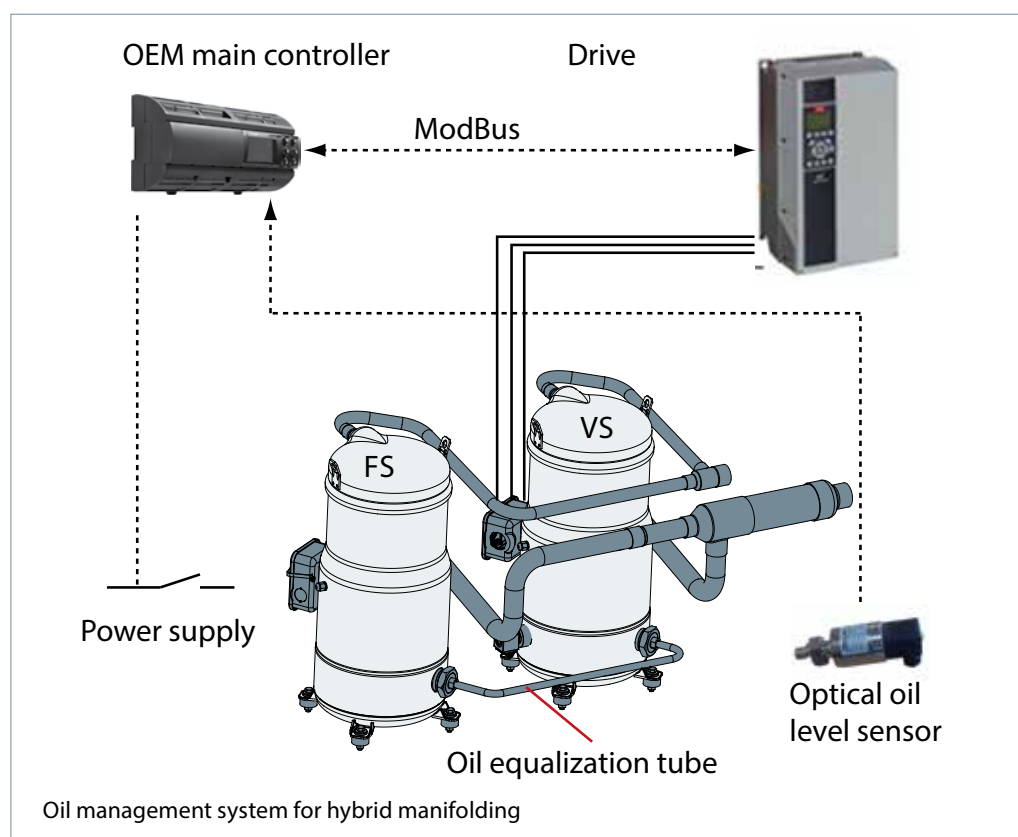
ORDERING INFORMATION

Oil Management logic

1. Oil management for hybrid manifold system

An oil level sensor needs to be installed on the variable speed compressor. The oil level is permanently monitored by OEM main controller. When oil level is below the minimal, OEM

controller enters in oil management mode to recover a proper oil level in compressor. If oil level cannot be recovered, controller stops the system.



2. Oil management description

2.1 Basic rules

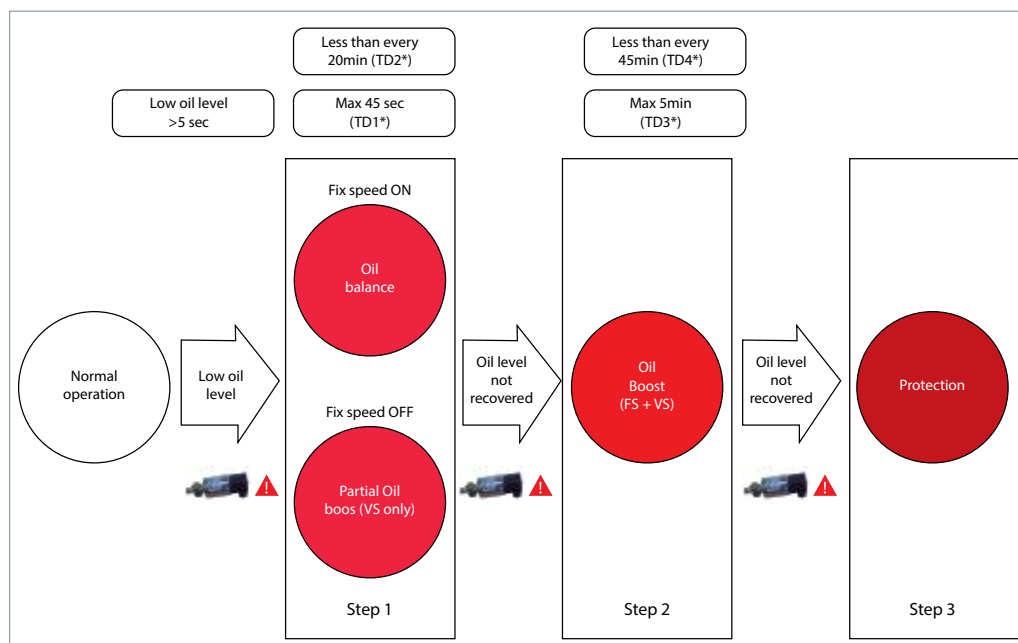
This specification describes the control logic to implement in OEM controller. This control logic must be implemented and thoroughly tested by OEM.

The variable speed compressor (VS) is primary and the fixed speed compressor (FS) is Secondary. FS must not run alone.

As oil balancing logic needs to start / stop compressor as well as increase / decrease speed, make sure expansion device is fast enough to maintain liquid flood back within acceptable limit during those transients (Manage super heat chapter).

2.2 Oil management modes

The oil management control logic must include 3 steps.



Step 1 (Oil balance or partial oil boost)

In case of low oil level detection by Oil level sensor on VS, there is 2 possible actions according to fix speed state:

- Fix speed is ON: Oil can be trapped in fix speed compressor due to pressure unbalance. Oil balance mode is activated. FS is stopped and VS speed is increased; pressure in VS become lower than FS oil is coming back through oil equalization line.
- Fix speed is OFF: Oil is trapped in the system. Partial oil boost is activated. VS speed is increased to slightly increase refrigerant velocity in the system and recover oil, FS remain OFF

TD1 is the maximum time to complete Step 1: If oil is not recovered within TD1, switch to Step 2: If oil is recovered within TD1 come back to normal operation. TD2 is the minimum interval between two step 1. If step 1 is requested in less

than TD2 after last step 1, switch immediately to step 2.

Step 2 (Full oil boost)

If oil level cannot be recovered within defined time, oil is trapped in the system. Full oil boost is activated. (VS speed is increased and fix starts (if not already ON). It considerably increases refrigerant velocity in the system and recovers oil.

TD3 is the maximum time to complete step 2. If oil is not recovered within TD3 switch to step 3. If oil is recovered within TD3 come back to normal operation. TD4 is the minimum interval between two step 2. In case of low oil level detection within a time <TD4, switch to step 3.

Step 3 (Protection)

If oil is still lower than limit after completed step 1 & 2, or if oil level drop within a time <TD4, controller must enter in protection mode, and stop the system in alarm.

Note: TD time is adjustable. Please refer to "Parameter and variable table" in page 31.

Annex

2.3 Steps description

2.3.1 Oil balance

Function description

Balance oil from FS compressor to VS Compressor.

Enter condition

Low oil level in VS compressor detected by oil level sensor.

AND

FS compressor is ON

AND

$t2 > TD2$, Interval between two Oil balance / Oil boost is $> TD2$

Cancel condition

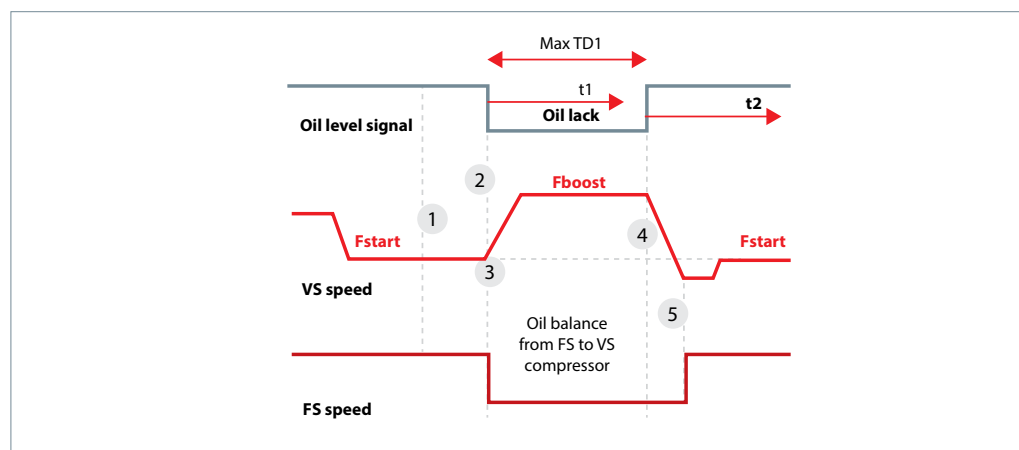
High oil level in VS compressor detected by oil level sensor.

OR

$t1 > TD1$, Oil balance duration exceed TD1

Control sequence

1. At the initial state, VS and FS compressor are ON.
2. Low oil level detected in VS compressor. Reset and Start $t1$.
3. FS compressor must stop. VS compressor speed must increase to Fboost.
4. When high oil level detected in VS compressor.
 - VS compressor speed must be decreased to minimal speed Fmin.
 - Reset and Start $t2$
 - Reset $t1$
- 5 When VS compressor speed reaches Fstart, FS compressor must restart.



Annex

2.3.2 Partial oil boost

Function description

Return oil trapped in the system to compressors by increasing refrigerant mass-flow in the system.

Enter condition

Low oil level in VS compressor detected by oil level sensor.

AND

FS compressor is OFF

AND

$t_2 > TD_2$, Interval between two Oil balance / Oil boost is $> TD_2$

Cancel condition

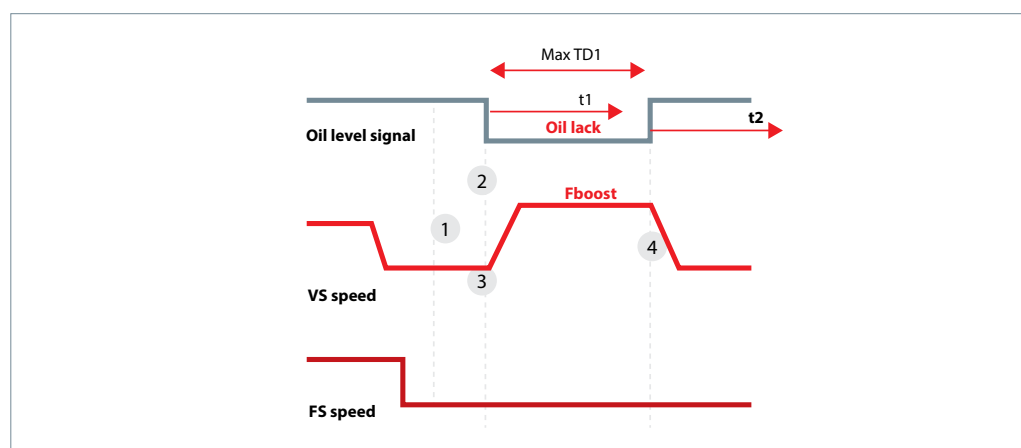
High oil level in VS compressor detected by oil level sensor.

OR

$t_1 > TD_1$, Partial oil Boost duration exceed TD_1

Control sequence

- 1 At the initial state, VS compressor is ON and FS compressor is OFF.
- 2 Low oil level detected in VS compressor. Reset and start t_1
- 3 VS compressor speed must increase to F_{boost} .
- 4 When high oil level detected in VS compressor
 - VS compressor speed must be decreased to the initial speed (F_{start})
 - Reset and start t_2
 - Reset t_1



Annex

2.3.3 Oil boost

Function description

Return oil trapped in the system to compressors by increasing refrigerant mass-flow in the system.

Enter condition

Low oil level in VS compressor detected by oil level sensor.

AND

($t_1 > TD1$, Oil balance / boost duration $t_1 > TD1$ OR $t_2 < TD2$, Interval between two Oil balance / Oil boost is $< TD2$)

Cancel condition

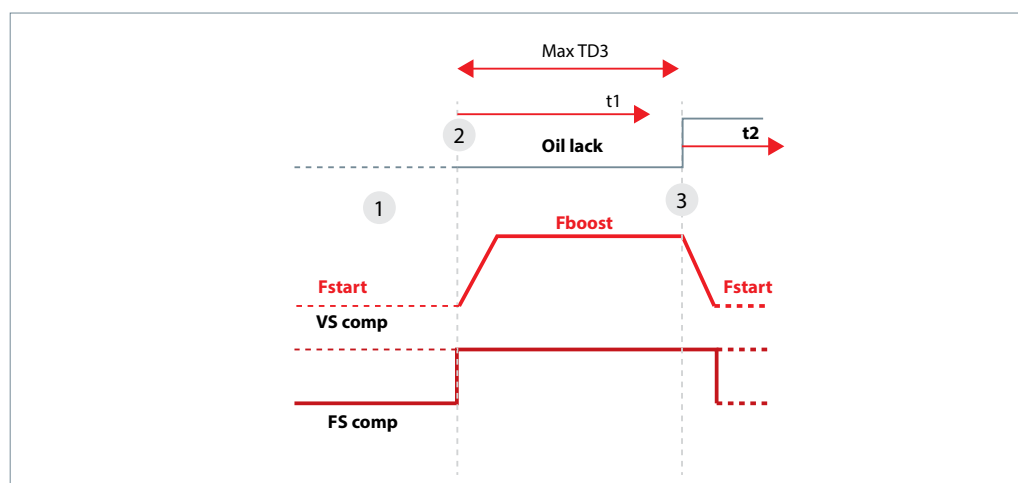
High oil level in VS compressor detected by oil level sensor.

OR

$t_1 > TD3$, Oil balance / boost duration exceeds Maximum Oil boost duration

Control sequence

1. At initial state, oil level is low. Partial oil boost / Oil balance was not successful or was aborted because minim interval criteria. VS compressor is at FStart and FS compressor is either ON or OFF.
2. VS compressor speed must increase to Fboost, FS compressor must start if not already ON
Reset and start t_1
3. When High oil level detected in VS compressor.
 - VS compressor speed must be decreased to the initial speed (Fstart)
 - FS compressor to initial state.
 - Reset and start t_2
 - Reset and start t_3
 - Reset t_1
4. When VS compressor speed reaches FStart, FS compressor must restart (if was ON before)



Annex

2.3.4 Protection

Function description

Stop compressors to prevent short of oil running.

Cancel condition

Manual Reset

Enter condition

Low oil level in VS compressor detected by oil level sensor.

AND

($t_1 > TD_3$, Oil balance / boost duration exceeds TD_3 OR $t_3 < TD_4$, Interval between two Oil boost is $< TD_4$)

Control sequence

Stop FS and VS compressor

Reset t_1

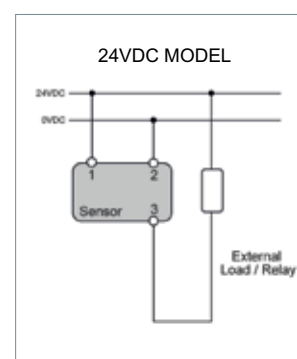
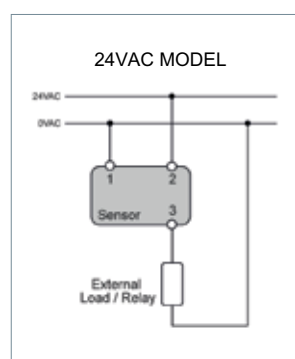
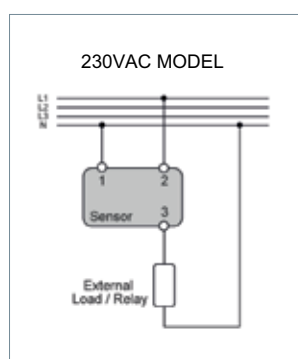
Reset t_2

Reset t_3

2.4 Parameter and variable table

| Name | Text | Attribute | Range | Default | Unit |
|--------|--------------------------------------------------------------|-----------|--------|---------|---------|
| Fboost | Boost action frequency | parameter | 25~100 | 70 | Hz |
| TD1 | Maximum oil balance / Partial oil boost duration | parameter | 10~240 | 30 | second |
| TD2 | Interval minimum between two oil balance / Partial oil boost | parameter | 10~60 | 20 | minutes |
| TD3 | Maximum boost duration | parameter | 5~12 | 5 | minutes |
| TD4 | Interval minimum between two oil boost | parameter | 45~120 | 45 | minutes |
| t_1 | Oil balance/ Partial oil boost timer | Variable | | | second |
| t_2 | Interval between two oil balance / Partial oil boost | Variable | | | minutes |
| t_3 | Interval between two oil boost | Variable | | | minutes |

2.5 Sensor Wiring diagram



An TEKLAB LC-XN optical-electrical level sensor is fixed on the inverter compressor. The oil level sensor monitors the compressor oil level and sends oil level signal to an external relay (provided by OEM). Regarding this oil level signal, a 5 ± 2 seconds delay is recommended to be used to consider the oil level fluctuation which may trigger false alarms.

- Lack of oil: Circuit between 2 and 3 will be opened internally, there will be no current

flowing through load or coil of external relay. For relay, output is open.

- Enough oil: Circuit between 2 and 3 will be closed internally, there will be current flowing through load or coil of external relay. For relay, output is closed

For customers who needs UL certificates, please order 24V AC/DC sensor.

Updates

Previous Version

- Page 10: Suction separator code
- Page 17: Refrigerant charge limit table
- Page 23: Suction separator code
- Page 24: Suction separator accessories

Current Version

- Page 10: Updated SH184 Left suction 60Hz in Suction separator code
- Page 17: Updated Refrigerant charge limit table
- Page 23: Updated VZH354 Left suction 60Hz in Suction separator code
- Page 24: Updated Suction separator accessories

Danfoss Commercial Compressors

is a worldwide manufacturer of compressors and condensing units for refrigeration and HVAC applications. With a wide range of high quality and innovative products we help your company to find the best possible energy efficient solution that respects the environment and reduces total life cycle costs.

We have 40 years of experience within the development of hermetic compressors which has brought us amongst the global leaders in our business, and positioned us as distinct variable speed technology specialists. Today we operate from engineering and manufacturing facilities spanning across three continents.



Danfoss Scrolls



Danfoss Inverter Scrolls



Danfoss Light Commercial Refrigeration Compressors



Danfoss Maneurop Reciprocating Compressors



Danfoss Turbocor Compressors



Danfoss Optyma Condensing Units

Our products can be found in a variety of applications such as rooftops, chillers, residential air conditioners, heatpumps, coldrooms, supermarkets, milk tank cooling and industrial cooling processes.

<http://cc.danfoss.com>

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